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Beugelsdijk, S.; Smulders, J.A.

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**BONDING AND BRIDGING SOCIAL CAPITAL AND ECONOMIC  
GROWTH**

By Sjoerd Beugelsdijk, Sjak Smulders

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# Bonding and Bridging Social Capital and Economic Growth

Sjoerd Beugelsdijk\* and Sjak Smulders\*\*

(February 2009)

## Abstract

In this paper we develop a formal model of economic growth and two types of social capital. Following extant literature, we model social capital as participation in two types of social networks: first, closed networks of family and friends, and, second, open networks that bridge different communities. Higher levels of social capital may *crowd out* economic growth through a reduction of working time. At the same time, participation in intercommunity networks reduces incentives for rent seeking and cheating, promoting economic growth. We test our hypotheses in a sample of European regions using unique data from the European Value Studies (EVS). Our findings show that it is important to distinguish between the nature of the social interaction.

**Keywords:** social capital, economic growth, Europe, regions

**JEL codes:** O40, R11, Z13

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\* Corresponding author: University of Groningen, Faculty of Economics and Business (IB&M), Nettelbosje 2, PO Box 800, 9700 AV Groningen; e-mail : s.beugelsdijk@rug.nl

\*\* Tilburg University, CentER/Department of Economics, Warandelaan 2, PO Box 90153, 5000 LE Tilburg.

## **Bonding and bridging social capital and economic growth**

### **Abstract**

In this paper we develop a formal model of economic growth and two types of social capital. Following extant literature, we model social capital as participation in two types of social networks: first, closed networks of family and friends, and, second, open networks that bridge different communities. Higher levels of social capital may *crowd out* economic growth through a reduction of working time. At the same time, participation in intercommunity networks reduces incentives for rent seeking and cheating, promoting economic growth. We test our hypotheses in a sample of European regions using unique data from the European Value Studies (EVS). Our findings show that it is important to distinguish between the nature of the social interaction.

**Keywords:** social capital, economic growth, Europe, regions

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## **Bonding and Bridging Social Capital and Economic Growth**

### **1. Introduction**

By now a vast literature on social capital exists. Since Putnam's seminal study on the role of social capital in Italian regions (Putnam, 1993), numerous scholars from different disciplines have contributed to our understanding of the antecedents and consequences of social capital (Knack and Keefer, 1997; Zak and Knack, 2001). Without going into a detailed discussion of all existing definitions of social capital (Sobel, 2002; Fine, 2001; Woolcock, 1998), it is important to specify how we understand social capital, exactly because of its multiple interpretations. We follow Durlauf and Fafchamps (2004) who present three main underlying ideas that return in almost all of the definitions of social capital; 'First, social capital generates (positive) externalities for members of a group. Second, these externalities are achieved through shared trust, norms, and values and their consequent effects on expectations and behavior. Third, shared trust, norms and values arise from informal forms of organization based on social networks and associations'. Hence, in their view, 'social capital is the study of network based processes that generate beneficial outcomes through norms of trust' (Durlauf and Fafchamps 2004, p. 5).

Although initially social capital was thought to be a one-dimensional construct that produces only positive outcomes, it is by now generally acknowledged that types of social capital exist, and that there is a dark side of social capital as well. In this respect Putnam (2000) distinguishes between two types of social capital, i.e. bonding and bridging social capital. The latter type can be defined as bonds of connectedness that are formed across diverse social groups, whereas bonding social capital cements only homogenous groups. A similar distinction in types of social capital has been proposed by others (Paxton, 1999; Fedderke et al. 1999; Woolcock, 1998), occasionally using different terminology but

referring to the same underlying phenomenon. For example, Tabellini (2008) and Platteau (1994) distinguish between limited versus generalized morality.

Despite its conceptual attractiveness, both theoretically and empirically, the (early) social capital studies yield a number of problems (Jackman and Miller, 1996; Manski, 2000; Paldam and Svendsen, 2000; Boggs, 2001; Fine, 2001; Durlauf, 2002a; Durlauf, 2002b; Sobel, 2002; Glaeser, 2000; Beugelsdijk *et. al.*, 2004; Beugelsdijk, 2008). Most of these critical approaches concentrate on the lack of a well-developed theoretical framework or methodical problems like the endogeneity of social capital. Moreover, there is little systematic quantitative evidence (Durlauf and Fafchamps, 2004) and formal modelling has just recently taken off (Tabellini, 2008; Francois, 2002; Alesina and Ferrara, 2000). As Bovenberg has put it, ‘theoretical models should be developed that define precisely the mechanisms through which various endogenous and exogenous variables interact. Subsequently the predictions of these models should be falsified’ (Bovenberg, 2003, p. 417). The added value of this paper lies precisely in the formal macroeconomic modelling and the empirical testing of the influence of different types of social capital on economic growth.

In our model, individuals endogenously choose how much time they spend on closed networks (bonding social capital) and open networks (bridging social capital), depending on their preferences and the opportunity costs (cf. Alesina and Ferrara, 2000). Both networks provide opportunities for social interaction, for which individuals have a preference. Participation in open networks has the side-effect of protection against opportunistic behaviour by others. Each individual also optimally chooses time spent on rent-seeking activities, on work and on investment and learning. At the aggregate level, participation in open networks (i.e. bridging capital) translates in civic engagement. If the level of civic engagement is high in society, opportunistic behaviour becomes less attractive for individuals and a more efficient system of exchange stimulates the economy (cf. Tabellini, 2008). We

formally link these mechanisms to investment and economic growth and show that more bridging social capital may (but need not) go together with faster growth. The reason why bridging capital is not necessarily good for growth is that it requires the maintenance of networks, which is a time-consuming process and comes at the cost of working time.<sup>1</sup>

As in Tabellini (2007), we analyze differences in economic growth rates across a sample of 54 European regions for the 1950-1998 period, and use the European Values Survey (EVS) to develop measures for our social capital measures. We show that bridging social capital has a positive effect on growth, whereas bonding social capital has a negative effect on the degree of sociability outside the closed social circle. This result supports Fukuyama's claim that 'the strength of the family bond implies a certain weakness in ties between individuals not related to one another' (Fukuyama, 1995, p. 56). Moreover, we show that an important mechanism that influences the degree to which people are willing to step out of their closed social circle and build bridging social capital depends on the materialistic attitude of that people. Since social capital is formed through network participation and social interaction in groups, it may well arise as a by-product of social interaction that is initiated mainly for other reasons. Man simply has a desire for socialising, just like it has a preference for food, shelter and material possessions (Simmel, 1908, 1950). Based on classical sociological insights, our argument is that there may be a trade-off between satisfying materialistic wants and desires for socialising. Materialistic attitudes may thus come at the cost of socialising and reduce the accumulation of social capital. People who are more materialistic tend to stick to the type of socialising that has a direct payoff, whereas less

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<sup>1</sup> It is important to note that for atomistic agents any form of social interaction – be it either bridging or bonding social capital – yields benefits. The issue is that bridging social capital has a larger (positive) impact on economic growth than bonding social capital. Hence, we do not claim that socialising with family and close friends is a bad activity as such. The crucial point is the distinction between types of socialising; investing in bridging social capital is better from a growth perspective. In this respect Putnam (2000) makes a relevant distinction between 'getting by' (bonding social capital) and 'getting ahead' (bridging social capital).

materialistic people are more embedded in social structures that do not directly yield materialistic or worldly advantages (Belk, 1984, 1985; Richins and Dawson, 1992).

Our empirical model closely follows the structure of our theoretical model. By doing so, we aim to counter (parts of) the criticism raised by Durlauf (2002b, p. F474) on the empirical literature on social capital. He writes that empirical studies seem to be particularly plagued by vague definition of concepts, poorly measured data, absence of appropriate exchangeability conditions, and lack of information necessary to make identification claims possible. Moreover, he argues that these problems are especially important as social capital arguments depend on underlying socio-psychological relations that are difficult to quantify, let alone measure. Our paper is a first and modest attempt to counter these criticisms. More in general, we contribute to the literature on culture and economic development, and the role of social capital in specific by showing that it is – both theoretically and empirically - important to distinguish between the nature of social interactions. This is an important conclusion as it informs the increasingly intense debate in economics on the role of social interactions for economic outcomes.

The remainder of our paper is structured as follows. We first present our formal model in which we describe the different channels through which the different types of social capital affect economic growth and what the role of materialistic attitude is. Then we test our set of hypotheses. Using a unique data set on norms and values in a sample of 54 European regions, we test the implications of our theoretical model.

## **2. A Formal Model of Bonding and Bridging Social Capital**

### ***2.1. Individuals' decision problem***

Individuals live for two periods. They work, consume and engage in social interaction when young, and consume when old. They care about produced consumption goods ( $c$  when young



and  $c_o$  when old) and social interaction<sup>2</sup> ( $s$ ). That is, their utility function has both material goods and social aspects as arguments:  $u = U(c, c_o, s)$ , with  $U_c, U_{c_o}, U_s > 0$ , where subscripts to function symbols denote (partial) derivatives. As argued above, we distinguish between two types of networks. First, social interaction takes place with close friends and family (which we categorize as f-networks). Second, networks consist of more remote contacts outside the family, within and outside the community one lives, in clubs, pubs and public meeting places, in voluntary organisations (called v-networks). In Putnam's (2000) terms, f-networks and v-networks represent bonding and bridging capital, respectively. Interacting with others is possible in both of these networks, so that they are substitutes to a certain degree in satisfying the individual's preference for social interaction. As Fukuyama argues 'People are embedded in a variety of social groups – families, neighbourhoods, networks, businesses churches, and nations – against whose interests they have to balance their own' (Fukuyama, 1995, p. 21). Hence, on balance the two are substitutes but imperfect ones in the utility function, which is reflected in the sub-utility function for satisfaction from social interaction ( $s$ ):  $s = S(f, v)$ , with  $S_f, S_v > 0$ . Here,  $f$  and  $v$  are the intensity of participation in f-networks and v-networks, respectively, to be measured by the time devoted to it.

Individuals choose how much they consume and how much they engage in social interaction. Social interaction (that is, maintaining social capital) requires time, which comes at the cost of working time. At the aggregate level this assumption is supported by the negative correlation of the number of working hours per year and the time invested in social networks (see appendix I). Thus there is a trade-off between social interaction and (future) material consumption. Through this channel, social interaction crowds out economic activity, so that the social capital created by social interaction has a negative effect on the economy.

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<sup>2</sup> From now on, when we write social interaction we mean socialising or sociability. In general, social interaction can also imply the fighting of a war, whereas socialising implies informal friendly social interaction. Nevertheless, in the remainder we restrict social interaction to the process of socialising.

To allow for a potential positive effect of social capital on the economy, we assume that social interaction in certain networks affects the degree of opportunistic behaviour. The idea is that agents engage in (time-consuming) rent seeking activities, by which we mean corruption and extorting, shirking and distrusting. By doing so they can effectively extract some of the income of others. However, participation in open networks ( $v$ ) protects agents against rent-seeking: people that are in the same open network never rob each other. As an example consider a shopkeeper, who is left with some products that are below his normal quality standard (say a grocer with some vegetables not so fresh anymore). He could mix high-quality goods and low-quality goods and sell all of them as high-quality goods. The customers might notice the low quality only when they are at home. But then they do not find it worthwhile to return to the shop and complain. The shopkeeper might also refrain from selling the low quality goods, or might sell them at a discount with the explicit warning about the quality. The shopkeeper is arguably less inclined to cheat his customers, if he knows he will meet the customer at another occasion, in particular when socialising with the same person.

The idea is that open networks act like bridging capital in connecting different groups. Within these networks, participants build up reputation and show trustworthiness in order to be able to derive value from social interaction across the groups represented in the network. Thus, while the desire for social interaction is the primary reason to join the network, trust and protection against rent-seeking is created as a side-product.

To be precise, let  $z$  be the time devoted to preparing rent-seeking activities. Rent-seeking implies randomly selecting a number of persons and extracting income from them. The most direct interpretation of income extraction is simply theft or robbery. Many more indirect interpretations are possible also: shopkeepers may exploit uninformed customers by selling goods of inferior quality; workers may cheat employers by shirking; one might think

of opportunistic behaviour in general. Obviously, we assume rent-seeking is directed at persons outside your own community (i.e. outside the  $f$ -network). However, you may run the risk that some of your rent-seeking activity affects fellows from your  $v$ -network, something you can only avoid after you have already spent the time preparing the rent-seeking activities (that is after choosing  $z$ ). We also assume you actually want to avoid damage to fellows from your  $v$ -networks, because they can exploit the network for some punishment or ostracism strategy.

On average a fraction  $B(z)$  of the average wage of a person you target can be extracted. However, only persons with whom one has no ties through  $v$ -networks will be eventually robbed, so the expected net benefit is  $(1-v)B(z)\bar{w}$ , where  $\bar{w}$  denotes the average wage and  $v \in [0,1]$  represents the probability that you meet somebody from your own  $v$ -network.

Rents extracted from others amount to positive transfers to you. However, rents being extracted from you amount to negative transfers. The latter are higher, the higher is your wage, the more rent-seeking prevails in society and the smaller is the number of fellows in your  $v$ -network who will abstain from robbing you. These (gross) negative transfers can be expressed as  $(1-v)\overline{D(z)w}$ , where  $D(z)$  is the damage from being robbed per unit of wage income as a function of rentseeking activity, and  $\overline{\phantom{x}}$  denotes the average level in society. Thus, net transfers are  $(1-v)[B(z)\bar{w} - \overline{D(z)w}]$ , with  $B_z > 0, D_z > 0$ .

Finally we assume that agents can invest in production skills when young. Their wage income,  $w$ , depends positively on the amount of time spent learning,  $l$ . Hence, we may write  $w = W(l)$ , with  $W_l > 0$ .

Since social interaction, rent seeking, and learning are time-consuming activities, they come at the cost of time devoted to work. With total time endowment normalized to unity, total time available for work equals  $(1 - v - f - z - l)$ .

We can now write down the complete decision problem of the individual agent. Choosing specifications for the utility functions and learning functions, we write:

$$\text{maximize} \quad u = U(c, c_o, s) = \mu(\ln c + \delta \ln c_o) + \ln s, \quad (1)$$

$$\text{subject to} \quad s = S(f, v) = \left( \phi^{1/\sigma} f^{(\sigma-1)/\sigma} + v^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad (2)$$

$$c + \frac{c_o}{1+r} = (1 - v - f - z - l)w + (1 - v)[B(z)\bar{w} - D(\bar{z})w]. \quad (3)$$

$$w = W(l) = w_h e^{\psi l} \quad (4)$$

We specify utility  $U$  as a time-separable Cobb-Douglas utility function. The importance of material consumption relative to social interaction is parameterized by  $\mu$  and will be referred to as the materialism preference parameter. The utility discount factor is  $\delta < 1$ . For sub-utility  $S(v, f)$ , we assume a constant elasticity of substitution  $\sigma$  between the two types of social networks. The importance of  $f$ -networks relative to  $v$ -networks is captured by parameter  $\phi$ , which will be referred to as the family ties preference parameter. The third line is the intertemporal budget constraint: net present value of consumption equals income from work plus net benefits from rent seeking. Finally, the learning function is exponential (consistent with Mincer's (1974) classical results) with  $\psi$  denoting the returns to learning. In particular,  $e^{\psi l}$  can be interpreted as the skill level and  $w_h$  as the wage per unit of skills. Since we model only one type of investment in "traditional" (non-social) capital, we interpret  $\psi$  more generally as the productivity of (non-social) investment.

The individual takes as given the average wage and loss from rent seeking in society ( $\bar{w}$  and  $\overline{D(z)}$ , respectively). The first-order conditions for a maximum can be written as:

$$(1-v)B_z(z)\bar{w} = w, \quad (5)$$

$$\frac{S_v(f, v; \phi)}{S_f(f, v; \phi)} = 1 - \left[ \overline{D(z)} - B(z) \frac{\bar{w}}{w} \right], \quad (6)$$

$$\frac{\mu S(f, v; \phi)}{c} = \frac{S_f(f, v; \phi)}{w}, \quad (7)$$

$$c_o = \delta(1+r)c, \quad (8)$$

$$\psi e^{\psi l} w_h [(1-v)(1-D(\bar{z})) - f - z - l] = e^{\psi l} w_h. \quad (9)$$

Equation (5) is the condition for optimal rent-seeking: it states that the marginal benefits of rent-seeking (marginal expected gross transfers, left-hand side) should equal the marginal opportunity cost (the wage on foregone labour time, right-hand side). Equation (6) determines the optimal trade-off between the two types of network interaction. The left-hand side represents the amount of time devoted to v-networks an individual is maximally willing to give up in exchange for an additional unit of time devoted to v-network participation (marginal rate of substitution). The right-hand side gives the opportunity cost of engaging in f-network participation rather than in v-network participation (marginal rate of transformation). Spending time with friends has a relatively low cost compared to spending time in extra-community networks if the net loss from rent-seeking (term in brackets) is high. Equation (7) determines the optimal trade-off between the material consumption and social interaction in f-networks: the benefits from additional family time,  $U_s S_f = S_f / s$ , should equal the opportunity costs in terms of foregone income that can be spend on consumption goods,  $U_c w = w\mu / c$ . Equation (8) is the well-known Euler equation for consumption: consumption increases over time with the rate of return on savings,  $r$ , and the degree of

patience as measured by the discount factor  $\delta$ . Finally, equation (9) characterizes optimal investment in human capital by equating marginal benefits and costs of learning. As shown at the left-hand side, learning raises human capital by  $\psi e^{\psi t}$  units, which increases earnings at wage rate  $w_h$  for each unit of time that human capital is employed (the term in brackets represents this working time). The right-hand side represents the marginal costs of learning, which consist of wages forgone because learning time comes at the cost of working time.

## 2.2. Solving for investment in production skills and social capital

The decisions of the individual agent depend on the society-wide variables like average rent-seeking, which in turn depend on the decisions of others. To solve for the macro-economic levels of the variables, we employ the simple assumption of complete symmetry: all agents have the same preferences and income and will make the same choices. Hence we have

$$\bar{w} = w, \overline{D(z)} = D(z). \quad (10)$$

We assume that if all agents engage in the same intensity of rent-seeking, the losses are a constant factor  $1 + \zeta$  larger than the benefits:

$$D(z) = (1 + \zeta)B(z), \quad \zeta > 0. \quad (11)$$

Thus rent-seeking is a negative sum game: what the extorter gains, is less than the damage to the person being extorted. Part of the transfer may be lost “in the battle” or confiscated by authorities. One might also see this as an implicit way of modelling the costs that the victim has to incur to avoid cheating and shirking (monitoring costs). Parameter  $\zeta$  captures this externality cost of rent-seeking.<sup>3</sup>

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<sup>3</sup> We think that it is realistic to add this negative externality. However, all our qualitative results go through when  $\zeta=0$ .

Our main question in this subsection is how investment in production skills ( $l$ ) and bridging social capital ( $v$ ) are related. Note that both variables are endogenous. Therefore, we need to identify how variations in exogenous variables simultaneously affect economic performance and social capital. The exogenous driving forces in the model are investment productivity ( $\psi$ ), preference for family-and-friends ties ( $\phi$ ), and preference for material consumption (materialism  $\mu$ ). We reduce the model to two equations in terms of the endogenous variables  $l$  and  $v$  and the exogenous variables  $\psi, \phi, \mu$ .

First, we denote by  $Z(v)$  the privately optimal level of rent seeking, as a negative function of  $v$ -networks, which follows from (5) after substitution of (10):

$$z = Z(v), \quad Z_v < 0. \quad (12)$$

Substituting (12) and (11) into (6), we find that  $f$  is a positive function of  $v$  and  $\phi$ :

$$f = F(v; \phi), \quad F_v, F_\phi > 0. \quad (13)$$

Solving (9) for  $l$  and substituting (10)-(13), we find desired learning time as a function of  $v$  and exogenous variables:

$$\begin{aligned} l &= [1 - v - F(v; \phi) - Z(v) - (1 - v)D(Z(v))] - 1/\psi \\ &\equiv L(v; \phi, \psi), \quad L_\phi < 0, L_\psi > 0, \end{aligned} \quad (14)$$

This key result reveals that networks have an impact on investment in production skills ( $l$ ) through five channels (corresponding to the five places where  $v$  shows up in the equation). First, more social interaction in  $v$ -networks directly reduces labour time and hence

reduces the returns to investment in production skills (see second term in brackets). Second, different types of social networking are positively correlated, so an increase in  $v$ -networking also increases time spent with friends and family and further reduces working time (third term in brackets). Together, we call these effects the *labour time crowding out effect*. The other three effects stem from the fact that  $v$ -capital protects against rent-seeking. In more dense social networks, there is less rent-seeking, so that not only time is freed up for production (fourth term in brackets, recall that  $Z$  depends negatively on  $v$ ), but also the negative sum externality is smaller (through lower probability that non-members meet and rob each other and through the smaller rent-seeking effort  $z$ ). Whether the returns to investment in production skills is positively or negatively related with  $v$ -networks thus depends on whether the negative labour time crowding out effect dominates or not the positive protection against rent-seeking effect (see appendix II, equation (A.10)).

Equation (14) also reveals that materialism ( $\mu$ ) has no direct impact on the economy, but can have an indirect impact only through affecting  $v$ . We substitute all first-order conditions into the budget constraint to solve for  $v$ . In particular, substituting first-order conditions (7)-(9) and (12)-(13) into the budget constraint (3) to eliminate  $z, f, l, c_o$ , and  $c$ , we find:

$$\mu(1 + \delta) = \frac{S_f(F(v; \phi), v)}{S(F(v; \phi), v)} [1/\psi + (1 - v)B(Z(v))]. \quad (15)$$

This is an implicit function in  $v$  only, so we may write (if we assume a unique solution):

$$v = V(\phi, \mu, \psi), \quad V_\phi, V_\mu, V_\psi < 0. \quad (16)$$



Equations (14) and (16) solve for equilibrium values of bridging capital  $v$  and learning time  $l$ . In appendix II we prove that  $v$  decreases with  $\phi$ ,  $\mu$ , and  $\psi$ , and that  $l$  increases with  $\psi$  while the effect of a rise in  $\mu$  or  $\phi$  is ambiguous.

We illustrate the working of our model by showing the effects of an increase in the materialism preference parameter ( $\mu$ ), which is a key determinant in our analysis. More materialistic attitudes reduce time engaged in bridging networks, see (16). Whether this increases or decreases investment in production skills depends on the sign of  $L_v$  in (14). If the “labour time crowding out effect” dominates, the sign is negative; then investment rises when and bridging social capital falls when attitudes become more materialistic. The opposite happens when the “protection against rent-seeking effect” dominates;  $L_v$  is positive and both investment and social capital fall with more materialistic attitudes. Hence, materialism affects investment in the economy (as measured by a change in  $l$ ) through a change in voluntary organizations (according to the relationship between  $v$  and  $l$  in (14)), but whether it boosts or hurt the economy depends on the relative strength of the crowding-out effect and protection-against-rent-seeking effect.

Analyzing changes in the other parameters in a similar way (and resorting to the mathematics in appendix II to make results more precise), we find the comparative statics displayed in Table 1. For example, a rise in the family ties preference parameter ( $\phi$ ) reduces bridging social capital (as measured by  $v$ , see the minus signs in the fourth column), and may reduce investment in production skills (see fourth column).

**Table 1:** Comparative statics

	Materialism ( $\mu$ )		Family ties ( $\phi$ )		Investment productivity ( $\psi$ )	
	$l$	$v$	$l$	$v$	$l$	$v$
Labor time crowding out dominates ( $\varepsilon_{Lv} < 0$ )*	+	−	?	−	+	−
Protection against rent seeking dominates ( $0 < \varepsilon_{Lv}$ )*	−	−	−	−	+	−

\* See appendix II for exact solutions.

### 2.3 Firms and regional output growth

Aggregate production in a region ( $Y$ ) is a Cobb-Douglas function of physical capital ( $K$ ), effective labor input ( $H$ ), and technology ( $A$ ),  $Y = AK^\beta H^{1-\beta}$ . Firms produce under perfect competition. Physical capital is regionally mobile so that the supply of capital is perfectly elastic at the exogenously given international interest rate  $r$ . This implies that wages equal  $w_h = (1 - \beta)Y / H$  and that aggregate regional output can be written as:<sup>4</sup>

$$Y = (\beta / r)^{\beta/(1-\beta)} A^{1/(1-\beta)} H, \quad (17)$$

Hence, growth in the technology level ( $A$ ) and effective labor input ( $H$ ) drives output growth.

The effective labor supply equals the labor time adjusted for their production skills (or human capital). Each agent supplies  $(1 - v - f - z)e^{\psi l}$  units of (effective) labor at the wage  $w_h$ , but  $(1 - v)\zeta B(z)e^{\psi l}$  units ultimately do not result in regional output, because they get lost

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<sup>4</sup> We derive this result as follows. From the demand for capital,  $A\beta K^{\beta-1} H^{1-\beta} = r$ , we can solve for  $K$ . We substitute this solution into the production function to arrive at (17).

in the process of rent seeking.<sup>5</sup> Aggregate effective labor input is therefore (where  $N$  is the number of agents, or population size):

$$H = N \cdot [(1 - \nu)(1 - \zeta B) - f - z] \cdot e^{\psi l}. \quad (18)$$

The level of technology a country can exploit ( $A$ ) results from technological innovation and absorption of foreign technologies. As in Nelson and Phelps (1966, cf. Bils and Klenow, 2000), a larger level of human capital per worker facilitates the absorption of foreign technologies. We choose the following specification for technological change:<sup>6</sup>

$$d \ln A / dt = \alpha \ln(\bar{A} / A) + \lambda \psi l, \quad (19)$$

where  $\bar{A}$  is the level of technology in the rest of the world from which a region can learn. The first term captures convergence through catching-up. Regions with relatively large technology gaps with other regions,  $\bar{A} / A$ , benefit from a relatively large pool of technologies to absorb from other regions, they realize relatively fast technical change until most technologies are absorbed and technological change slows down. The second term indicates that a region's productivity gap converges to a level that depends positively on the level of human capital.<sup>7</sup>

Growth of per capita output can now be calculated from (17), (18) and (19) as:

$$g_y = \alpha \ln(\bar{Y} / H) - \alpha \ln y + \left[ \alpha \ln(1 - \nu - f - z) + \left( \alpha + \frac{\lambda}{1 - \beta} \right) \psi l \right], \quad (20)$$

<sup>5</sup> We do not subtract learning time. Thus we integrate the learning sector (education, training and consultancy) in our measure of output  $Y$ .

<sup>6</sup> Although our model relies on a specific way of modeling growth through technical change and human capital accumulation (Bils and Klenow, 2000, who build on Nelson and Phelps, 1966; and Mincer, 1974), the results carry over to other standard growth frameworks (e.g. Lucas, 1988; Rebelo, 1991). The time crowding out effect implies lower utilization of any kind of capital (or input) in the economic production process (for example physical capital, human capital). This reduces the incentives to invest in these capital goods (or inputs). Protection against rent seeking implies that the returns from investment can be better appropriated and thus stimulates investment and growth.

<sup>7</sup> In the long run,  $A / \bar{A}$  is constant at level  $\ln A / \bar{A} = \alpha / [(d \ln \bar{A} / dt) - \lambda \psi l]$

where per capita output is denoted by  $y \equiv Y/N$ , where we have used (17) to eliminate  $\bar{A}/A$  and  $\bar{Y}/\bar{H}$  is the average income per unit of human capital in rest of the world.<sup>8</sup> We can identify the driving forces behind growth by the three terms at the right-hand side of equation (20): foreign income levels, own income levels, and the term in brackets, which can be written in terms of social capital  $v$  and the parameters  $\phi$  and  $\psi$  only (see (11)-(14)). The first term captures spillover effect: rich neighboring regions provide a region with the opportunities to learn from and grow faster. The second term captures beta-convergence: poor countries grow faster than rich countries, *ceteris paribus*, due to technological catch-up. The third term at the right-hand side of (20) captures the effect of social capital on growth. Note that the sign is ambiguous because the labor time allocation effect may or may not be dominated by the protection against rent-seeking effect. Also the effect of  $\psi$  is ambiguous: on the one hand a higher productivity of learning enhances human capital, on the other hand it reduces hours worked.

## ***2.4 Implications from the model***

In the theoretical model, the following results have been derived about the relationship between growth and social interaction.

- Growth and bridging social capital are endogenous variables, which are simultaneously determined by attitudes towards spending time with friends and family, materialism, and the productivity of investment.
- Controlling for family ties, initial income, and productivity of investment, an exogenous increase in bridging social capital may affect growth negatively or

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<sup>8</sup> We have also used the fact that  $l$ ,  $v$ ,  $f$ , and  $z$  are constant over time according to the model. When testing the model, these terms are expected to be relatively small. Moreover, no time series data is available for these variables.

positively. In the former case, the time cost of networking dominates the productive benefits. The latter case arises if the protection of bridging capital against rent-seeking is strong enough (see equations (20) and (14)).

- Materialism affects growth only through bridging social capital. Interesting to note is that materialism may be good or bad for growth. In particular, if the protection against rent-seeking effect dominates, more materialism leads to lower bridging capital and thus to lower growth.
- Family ties, investment and materialism negatively affect bridging capital. Initial income does not affect bridging capital (see (16)).

### **3. An Empirical Test of Our Hypotheses**

#### ***3.1 Measurement***

In order to test the above hypotheses we investigate growth rates across 54 European regions. By taking regions, we are able to test if Putnam's thesis on social capital based on Italian regions can be generalized (Putnam, 1993, Tabellini, 2007). Moreover, a European regional approach allows us to incorporate Temple's critical comment (1999) that countries differing widely in social, political and institutional characteristics are unlikely to fall on a common surface. Most important, however, is the fact that by comparing *national* cultures, 'we risk losing track of the enormous diversity found within many of the major nations of the world' (Smith and Bond 1998, 41). By studying regions and regional differences this risk is limited.

Data on social capital are taken from the European Value Studies (EVS), which is a survey on norms and values. The European Value Study is a large-scale, cross-national, and longitudinal survey research program on basic human values, initiated by the European Value Systems Study Group (EVSSG) in the late 1970s. The EVS aimed at designing and conducting a major empirical study of the moral and social values underlying European social and political institutions and governing conduct. Of the three survey waves (1981,

1990, and 1999) we use the second one. For reasons of availability of social capital variables and the possibility of a regional breakdown we are not able to use the other waves. The set comprises 7 countries, i.e. France, Italy, Germany, Spain, The Netherlands, Belgium, and the United Kingdom. Our regional approach implies that France consists of 8 regions, Italy 11, Germany 11 (former eastern regions excluded), Spain 7, The Netherlands 4, Belgium 3, and the UK 10 (including Scotland, excluding Northern Ireland). The total number of regions equals 54. This regional classification is based on the European Statistical Office (Eurostat), as are our economic data.

#### *A basic empirical regional growth model*

In crafting our empirical model, we follow Barro and Sala-i-Martin (1995) who explain regional growth differentials in Europe between 1950 and 1990. As we have more recent economic data, we analyze the period 1950-1998.<sup>9</sup> To test the growth part of our theoretical model, we use their standard growth framework, in which economic growth is explained by a number of key economic variables (Baumol, 1986; Barro, 1991; Mankiw et. al., 1992; Barro and Sala-i-Martin, 1995). We include initial per capita income of the region. Our proxies for the productivity of investment are educational attainment and national investment rates. Since regional investment rates are not available, we take the national rates from the Penn World Tables.<sup>10</sup> Further, the idea is that years of schooling facilitate learning on the job (which was theoretically modeled by variable  $l$ ). Regional schooling data is only available for a limited number of years, and measured by the total number of pupils at first and second level in 1977, divided by total number of people in the corresponding age group. The school enrolment rate in 1977 falls in between these dates and given the fact that school enrolment

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<sup>9</sup> For reasons of robustness, we also observed shorter periods of analyses for our dependent variable, e.g. the period 1970-1998.

<sup>10</sup> Eurostat and Cambridge Econometrics do provide data on Gross Fixed Capital Formation. However, data are incomplete for some countries or in time.

rates have increased since 1950, the 1977 information may be a reasonable proxy for the average over the entire period. Data on school enrolment rates in Spanish regions refer to 1985.

As is common in regional growth analyses we also include a measure to control for the level of welfare of neighbouring regions. Low initial income and large spillovers from other regions may stimulate growth by the convergence measure. Ideally one should use interregional input-output tables to calculate regional multipliers and construct a variable that controls for spatial correlation.<sup>11</sup> However, this information was not available. In order to control for spatial correlation, we applied Quah's (1996) approach and calculated the so-called neighbour relative income. This method implies that we use average per capita income of the surrounding, physically contiguous regions to control for spatial auto-correlation. Hence, spillovers are measured as the average income of the regions adjacent to the focal region. In addition we use a measure for the concentration of human capital in agglomerations (created by the interaction of a dummy variable indicating the major agglomerations in a country and the school enrolment ratio).<sup>12</sup> Regions in which large agglomerations are present may benefit from scale economics, concentration of human capital, the presence of a cluster of specialized suppliers, and a market with a critical mass of consumers (network externalities).

### *Bridging social capital*

Following Knack and Keefer (1997), we measure bridging social capital by the density of associational activity, or in other words the average per capita membership of an association.

Of the associations mentioned in the EVS data, we have used membership of the following

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<sup>11</sup> There exist other ways to have a more refined control variable that can be taken into consideration, for example the physical length of abutting boundaries or the physical characteristics of the border terrain. However, these kinds of extensions go beyond the scope of this paper.

<sup>12</sup> We selected the Western part of the Netherlands, Greater Paris, Greater Berlin, Greater London, Barcelona area, Brussels, and the Italian region Lazio (Rome) as major agglomerations.

groups: a) Religious or church organizations, b) Education, arts, music, cultural activities, c) Youth work (e.g. scouts, guides, youth clubs), d) Sports or recreation, and e) Women's groups. The groups mentioned under a, b and c were also used by Knack and Keefer (1997) in their analysis. We have chosen to add d and e as they also proxy associational activity that is *not* focused on rent seeking activities that can be expected from groups such as political parties and professional associations.<sup>13</sup> We expect the selected groups to involve social interaction that builds trust and cooperative habits, which is the reason why we label it bridging social capital. The average score of the density of group membership in 54 European regions equals .34 with a standard deviation of .18. The highest score (.80) is obtained in the eastern part of the Netherlands (Oost-Nederland), and the lowest score (.08) in the North-Eastern part of Spain (Noroeste). All data are based on 1990 information.

#### *Bonding social capital and family ties*

We measure preferences for family ties (preference parameter  $\phi$  in the model) by EVS data on the relative importance of the closed social circle.<sup>14</sup> On a scale of 1-4 (very important – not at all important) respondents are asked to indicate the importance in their life of family, and friends and acquaintances. By using factor analysis we re-scaled the two items in one dimension reflecting bonding social capital. Both on the individual and the regional level the chosen items converge into one dimension. The regions where people attach the highest value to the close social circle can be found in the southern part of Europe. The region with the

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<sup>13</sup> Olson (1982) observed that associational activity may hurt growth because of rent-seeking activities. According to Olson, many of these associations may act as special interest groups lobbying for preferential policies that impose disproportionate costs on society. In this respect, Knack and Keefer (1997) distinguish between what they call Putnam and Olson groups.

<sup>14</sup> We have no measures of time spent in closed networks (bonding social capital). This means that we cannot test equation (13) of the model. In other words, we look at purely stated preference instead of revealed preference with respect to bonding social capital. Instead, for bridging capital we use a measure closer to a revealed preference indicator (actual network participation).



highest score on bonding social capital is the French Mediterranean and the region where people attach least importance to family and friends is the German region Bremen.

### *Materialism*

To operationalise the degree of materialistic attitude towards society we use two proxies. First we use the well-known materialism-postmaterialism index introduced and developed by Inglehart (1997) and Inglehart and Baker (2000). It is based on the relative importance respondents attach to the following items: a) Maintaining order in the nation, b) Giving people more say in important government decisions, c) Fighting rising prices and d) Protecting freedom of speech. Of each of these four statements respondents are asked to indicate the most important and the next most important statement. The materialist/postmaterialist value is created as follows. If the respondent's first and second choices are both materialist items (i.e. maintaining order and fighting rising prices), the score is '1'. If the respondent's first and second choices are both postmaterialist items (i.e. giving people more say and protecting free speech), the score is '3'. If the two choices are any mixture of materialist and postmaterialist items, the score is '2'. In sum, a high score on this variable reflects a postmaterialistic attitude and a *low score reflects a materialistic attitude*. The mean score equals 2.04 with a maximum value of 2.29 in the region Berlin (Germany). The most materialistic according to Inglehart's materialism index are the people in the Italian region Campania (1.68).

In addition to Inglehart's materialism measure, we use a second proxy. Our EVS dataset contains several questions on the importance people attach to various aspects of a job. Based on the question 'which of the following aspects of a job you personally think are

important?’ respondents are asked to indicate a number of aspects.<sup>15</sup> Among these aspects some refer to materialistic values (e.g. good pay) and others to immaterialistic values (e.g. useful job for society). We selected the following items that reflect an immaterialistic attitude towards a job: a) pleasant people to work with; b) a useful job for society; and c) meeting people. Using principal components analysis we re-scaled these items into one dimension and aggregated the individual scores to mean scores for each of our 54 regions. The variable is scaled from immaterialistic to materialistic. We choose to label this variable job-related materialism. Hence, high scores on the variable *job related materialism* reflect a materialistic attitude. The highest score (most materialistic) is obtained in the French region Sud-Ouest. The lowest score can be found in the eastern part of the Netherlands. Table 2 presents descriptive statistics of the variables defined above and used in the empirical tests.

**Table 2:** Descriptive Statistics

	Mean	Std. Dev.
Bonding social capital	-.077	.17
Bridging social capital	.34	.18
Materialism-Postmaterialism (Inglehart)	2.04	.13
Job-related Materialism	.059	.28
Investment	24.25	3.74
Schooling	.51	.067
Growth 1950-1998	.029	.33
Initial income	-.003	.25

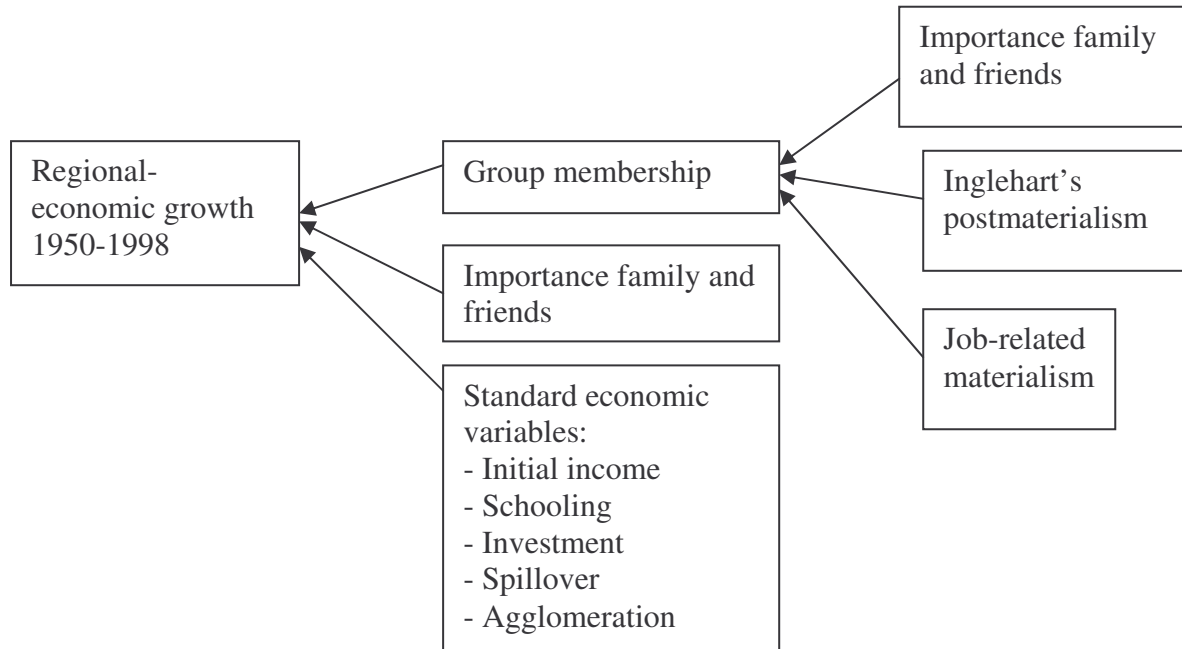
N=54. Growth is measured in percentage points. Initial income, as well as schooling, investment and bridging social capital are measured in logarithms.

<sup>15</sup> The total list of aspects respondents are asked to choose from is: good pay, pleasant people to work with, not too much pressure, good job security, good chances for promotion, a job respected by people in general, good hours, an opportunity to use initiative, a useful job for society, generous holidays, meeting people, a job in which you feel you can achieve something, a responsible job, a job that is interesting, a job that meets one’s abilities.

### 3.2 Testing our model

Figure 1 depicts our testing strategy.

**Figure 1:** graphical representation of the empirical model (c.f. model 1 in table 3)



Our aim is to test the model in figure 1. In particular, we are interested in the sign of the relationship between growth and bridging capital (proxied by group membership). Here we have to take into account that bridging social capital and growth are simultaneously determined. To avoid a simultaneity bias, we need to instrument for bridging social capital. Hence we use a two-stage least squares (2SLS) testing strategy.<sup>16</sup> In the first stage, we instrument social capital, by regressing our measure of bridging capital on our measures of materialism, family ties and investment productivity. Doing so, we test for the signs of the arrows in the North-East part of the figure (and of equation (16)). In the second stage, we use instrumented bridging social capital, together with investment and convergence measures, as regressors for growth. Doing so we test for the signs of the left-hand side of the figure (and of

<sup>16</sup> We have checked for a possible endogeneity bias by using a Hausman test. It is common to test whether it is necessary to use an instrumental variable and estimate a 2SLS regression, i.e., whether a set of estimates obtained by least squares is consistent or not. We performed an augmented regression and concluded that estimating an OLS would not yield consistent estimates.

equation (20) with (14) substituted). Needless to say, we are most interested in finding the empirically relevant sign of the relation between growth and bridging social capital which could not be determined a priori.

The results are summarized in table 3. We estimate different models. The first is our basic model in which our dependent variable is the average regional-economic growth of per capita income between 1950 and 1998. In addition to the basic model we estimate a number of other model specifications.

**Table 3: IV-regression**

<b>2<sup>nd</sup> Stage</b>	<b>Dependent variable: regional economic growth</b>				
	(1)	(2)	(3)	(4)	(5)
	Basic	Job-related Materialism excluded	Inglehart's Materialism excluded	Trust included as instrument	Regions excluded
Initial income	-.92 (.16)**	-.92 (.16)**	-.92 (.16)**	-.92 (.16)**	-.84 (.18)**
Schooling	.49 (.34)	.49 (.35)	.50 (.35)	.49 (.34)	.43 (.35)
Investment	.33 (.23)	.34 (.23)	.33 (.24)	.33 (.24)	.35 (.24)
Spillover	.28 (.12)**	.27 (.12)**	.28 (.12)**	.28 (.12)**	.27 (.13)**
Agglomeration	.43 (.24)*	.42 (.24)*	.44 (.24)*	.43 (.24)*	.37 (.24)
Bonding social capital	-.37 (.23)	-.36 (.23)	-.39 (.22)*	-.37 (.22)	-.35 (.23)
Bridging social capital	.17 (.08)**	.19 (.08)**	.14 (.09)	.17 (.08)**	.15 (.08)*
R-squared	.53	.53	.53	.53	.45
N	54	54	54	54	52

<b>1<sup>st</sup> Stage</b>	<b>Dependent variable: bridging social capital</b>				
Bonding social capital	-.81 (.37)**	-.63 (.38)*	-1.02 (.43)**	-.82 (.37)**	-.81 (.38)**
Job-related materialism	-.63 (.27)**	-	-1.35 (.24)**	-.57 (.29)**	-.63 (.28)**
Inglehart's Postmaterialism	2.53 (.60)**	3.42 (.49)**	-	2.46 (.61)**	2.56 (.62)**
Trust	-	-	-	.43 (.63)	-
R-squared	.58	.54	.43	.59	.58
N	54	54	54	54	52

Standard errors between parentheses. \* indicates 10% significance, \*\* indicates 5% significance. The basic equation refers to the growth period 1950-1998. We only reported the variables of interest in the first stage and excluded the other exogenous variables. In model 5 we excluded the regions that have the maximum and minimum residual in the second stage of the regression. The regions we excluded are Schleswig-Holstein (Germany) and Nord Ovest (Italy). The regression in model 6 is based on the basic regression as shown in model 1.

The basic model in column (1) shows that bridging social capital has a positive and significant effect on regional growth. Bonding social capital has the negative sign predicted by our model, but is insignificant in the second stage. However, in the first stage, bonding

social capital (or better, the preference for family ties) negatively affects bridging capital, a result in line with our model. Also materialism affects bridging capital negatively and significantly. The results on the effects of bridging capital on growth are worth being highlighted. Note that from the model we could not sign this effect unambiguously because of two opposing forces. Empirically, we find a positive effect, which means that bridging social capital is good for growth. This positive effect is statistically significant, but quite small in economic terms. A one percent standard deviation in bridging capital raises growth by only  $0.17 \cdot 0.18 = 0.03$  percentage points. An assessment of the economic significance of the result that is more consistent with our estimation procedure yields a stronger effect: a one standard deviation change in our three instruments (family ties and two types of materialism) raises growth through bridging capital by 0.11 percentage points. Over our 48 years sample period this amounts to the non-negligible increase of 5.4% in (last year's) regional income.

The social capital variables in the basic model perform even better than the traditional variables like schooling and investment, of which the coefficient is insignificant. While schooling is often a problematic variable in growth regressions (Krueger and Lindahl, 2001), investment usually is a robust variable (Levine and Renelt, 1991). Note however, that we included national rather than regional investment rates.

Model (2) shows the results when the variable Job related materialism is left out. Compared with the basic model this does not yield different results. Leaving out Inglehart's materialism index does however yield different results. As model (3) shows, bridging social capital is not significantly positively related to growth as it is in all the other models. The overall fit of the 1<sup>st</sup> stage model goes considerably down from .58 in model (1) to .43, suggesting it is important to include Inglehart's materialism index in the 1<sup>st</sup> stage.

Adding trust as an instrument to the first stage regression does not yield differences with the basic model. As shown by Beugelsdijk *et al.* (2004), the significance of trust in

growth regressions depends on the inclusion of a number of less developed countries. Given the European sample, the insignificant result is therefore not surprising (Beugelsdijk and Van Schaik, 2005). The results in table 3 suggest that trust is not *indirectly* related to growth either. The relation between trust and bridging social capital is not significant when we use trust as an instrument for bridging social capital. In case we add trust as an instrument and exclude the other instruments the above conclusion does not change.

In our final model we test if outliers determine the results obtained. We have left out the regions that had the highest and lowest residual in the second stage of our basic regression model (1). The regions excluded are Schleswig-Holstein (Germany) and Nord Ovest (Italy). The analysis for the reduced sample of 52 regions does not differ greatly of the results obtained in the basic regression on 54 regions. The main difference can be found in the fact that bridging social capital is not related to growth at the 5% significance level, but at 10% (though the reduction in significance is marginal, namely 6% versus 4%). We also excluded the observations with maximum and minimum value of growth (Bayern in Germany, resp. Nord Ovest in Northern Italy) and the maximum and minimum value for initial income (Hamburg, resp. South Italy). Thirdly, we used a so-called recursive method to check if the composition of the sample influenced our results. All these checks suggest that our results are robust with respect to the potential influence of outliers. Finally we have tested for alternative growth periods. Results (not shown, but available upon request) do not change our conclusion regarding the economic effects of the two types of social capital.

#### **4. Conclusion**

In this paper we have distinguished between bonding and bridging social capital. We have developed a model to formalize the link between these two types of social capital and economic growth and empirically tested our hypotheses. We identified two channels through

which social capital and economic growth are interrelated. First, network participation is a time-consuming process, which crowds out working and learning time and therefore tends to be negatively correlated with growth. Second, participation in networks that span different communities may create bridging social capital. Trust is generated in these networks, which protects members against rent-seeking activities. The reason is that participants that know each other from the same network restrain their opportunistic behavior towards each other, to maintain reputation within the group and to avoid ostracism or lighter forms of punishment.

By this second channel, the relationship between growth and social capital tends to be positive. Such a positive relationship does not exist for bonding social capital and economic growth. Bonding social capital arises from networking within own communities of close friends and family. Because opportunistic behavior is limited in one's own closed social circle, an increase in time spent with your own close circle does not reduce opportunistic behavior in the economy. Higher levels of bonding social capital are therefore likely to go together with lower rates of economic growth, since spending more time with family and close friends comes at the cost of working and learning time. Our empirical analysis of growth in 54 European regions confirms the importance of the distinction between these two kinds of social capital. Bridging social capital is empirically good for growth, while a large importance attached to family ties is negatively related to growth (though indirectly).

We have also stressed the fact that social capital is a choice variable that has to be explained from deeper economic and cultural variables. A central variable in our analysis is materialism. In our sample of European regions, we find that more importance attached to material possession is correlated with lower participation in voluntary organizations, which results in lower growth through reduced levels of bridging social capital. Apart from generating explicit results on social values and economic performance, our two-stage

approach also allowed us to address the simultaneity problems of which other studies have been criticized (Durlauf, 2002b).

Our first step in modelling and estimating the growth effect of bonding versus bridging capital calls for several next steps. First, an analysis of data on actual time spent with family and friends could make the role of bonding social capital more explicit. Also, by exploiting data on rent-seeking and corruption, we could try to measure our protection against rent-seeking effect directly. Unfortunately, this type of data on the regional level in Europe is hard to find. Second, better empirical results might be obtained if we no longer classify networks uniquely as either bonding or bridging. For example, we used the working hypothesis that membership of a sports club results into bridging social capital, but a soccer club can be rather bonding if all team players are from the same social class and district. Alternatively, family ties can be of a bridging character. Third, we may try to find a broader spectrum of variables, beyond materialistic values, that drive the choice between bonding and bridging social capital. The relative amount of bridging versus bonding may be a reflection of broader cultural values, of which materialism is an important component (Inglehart and Baker, 2000). Finally, the theoretical modeling can be refined, for example by explicitly modeling the microeconomics of reputation, opportunistic behaviour and efficiency losses from cheating. We are convinced that general equilibrium modelling with micro-economic foundation can further our insights in the link between social values and economic performance and can fruitfully guide the empirics of social capital and cultural values.



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## Appendix I:

One assumption in our model concerns the negative relation between time invested in social interaction and working time. To substantiate this assumption, the following table shows at the country level the average number of hours worked and the amount of bridging social capital. The correlation is negative (-.34) for the sample of 20 countries for which we have data. Acknowledging the extraordinary position of the United States regarding its relative dense network membership of church and religious associations (Inglehart and Baker, 2000), excluding the United States yields a correlation of -.47. All in all this negative correlation supports our assumption regarding the relationship between social interaction and working time.

	Bridging Social capital	# hours worked
Austria	1.00	1,683
Belgium	1.21	1,699
Canada	1.46	1,830
Denmark	1.05	1,492
Finland	1.30	1,677
France	0.46	1,558
Germany	0.65	1,541
Greece	0.88	1,912
Iceland	1.70	1,839
Ireland	0.87	1,922
Italy	0.58	1,674
Japan	0.62	1,956
Luxem	1.17	1,638
Nether-	2.49	1,414
Portugal	0.26	1,882
Spain	0.38	1,824
Sweden	2.10	1,546
Turkey	0.04	1,912
U.K.	0.43	1,698
USA	2.43	1,840
<b>Correlation</b>		
Full sample	-0.335	N=20
excl USA	-0.472	N=19

Source: Data on working hours are from the Groningen Growth and Development Center ([www.ggdc.net](http://www.ggdc.net)). The social capital measure is based on the measure as developed by Knack and Keefer (1997) and fully described in the empirical section of this paper. Social capital data is based on the World Values Survey. Both working hours and social capital refer to 1990 data.

## Appendix II: Comparative statics and stability

We linearize the first order conditions and the budget constraint. Using the first order condition for future consumption (8) to eliminate  $c_o$  (i.e. after substituting  $\tilde{c} = \tilde{c}_o$ , since  $r$  is a constant), and using the symmetry assumption, see (10) and (11), we find for the budget constraint and the other first order conditions, respectively:

$$\tilde{c} = \tilde{w} - \frac{w}{(1+\delta)c} \left\{ v\tilde{v} + f\tilde{f} + l\tilde{l} + (1-v)\zeta B \left[ \frac{-v}{1-v} \tilde{v} + \frac{B_z z}{B} \tilde{z} \right] \right\} \quad \text{BUDG (A.1)}$$

$$\frac{1}{\sigma_{cs}} [(1-\varepsilon_{sf})\tilde{v} + \varepsilon_{sf}\tilde{f} - \tilde{c} + \tilde{\mu}] = \frac{1}{\sigma_{vf}} \left[ (1-\varepsilon_{sf})(\tilde{v} - \tilde{f}) + \left( 1 + \frac{\varepsilon_{sf}}{\sigma_{vf} - 1} \right) \tilde{\phi} \right] - \tilde{w}, \quad \text{FOCs (A.2)}$$

$$\frac{1}{\sigma_{vf}} [\tilde{f} - \tilde{\phi} - \tilde{v}] = \frac{-\zeta B}{1-\zeta B} \frac{B_z z}{B} \tilde{z}, \quad \text{FOCf (A.3)}$$

$$\frac{B_{zz} z}{B_z} \tilde{z} - \frac{v}{1-v} \tilde{v} = 0, \quad \text{FOCz (A.4)}$$

$$\tilde{\Psi} - \Psi \left\{ v\tilde{v} + f\tilde{f} + z\tilde{z} + l\tilde{l} + (1-v)(1+\zeta)B \left[ \frac{-v}{1-v} \tilde{v} + \frac{B_z z}{B} \tilde{z} \right] \right\} = 0 \quad \text{FOCl (A.5)}$$

where variables with a tilde are logarithmic deviations from the initial equilibrium; variables without a tilde refer to the initial equilibrium,  $\varepsilon_{sf} = S_f f / S$ , and  $\sigma_{cs}$  is the elasticity of substitution between  $s$ ,  $c$ , and  $c_0$  in  $U$  ( $\sigma_{cs}=1$  in (1)).

We first consider the properties of the model if all variables are non-zero, postponing corner solutions and stability to below. Combining (A.4) and (A.3), we find:

$$\tilde{z} = -\varepsilon_{Zv+} \tilde{v}, \quad \text{(A.6)}$$

$$\tilde{f} = \varepsilon_{Fv} \tilde{v} + \tilde{\phi}, \quad \text{(A.7)}$$

where  $\varepsilon_{ij}$  denotes the elasticity of  $i$  with respect to  $j$ , and  $\varepsilon_{ij+}$  denotes the positively defined elasticity of  $i$  with respect to  $j$ :

$$\begin{aligned}\varepsilon_{Zv+} &= \frac{v}{1-v} / \frac{-B_{zz}z}{B_z} > 0, & \varepsilon_{Fv} &= 1 + \sigma_{vf} \frac{\zeta B}{1-\zeta B} \varepsilon_{Bz} \varepsilon_{Zv+} > 1. \\ \varepsilon_{Bz} &= B_z z / B > 0, & \varepsilon_{Sf} &= S_f f / S.\end{aligned}$$

Equations (A.6) and (A.7) give the properties (elasticities) of the functions  $Z$  and  $F$  in (12) and (13). Substituting (A.6) and (A.7) into (A.1), (A.2), and (A.5), respectively, we find:

$$\tilde{c} = \underbrace{\frac{w}{(1+\delta)c} [-v - f\varepsilon_{Fv} + z\varepsilon_{Zv+} + (v + (1-v)\varepsilon_{Bz}\varepsilon_{Zv+})\zeta B]}_{\equiv \varepsilon_{Tv}} \tilde{v} - \left( \frac{wl}{(1+\delta)c} \right) \tilde{l} - \left( \frac{fw}{(1+\delta)c} \right) \tilde{\phi} + \tilde{w}, \quad (\text{A.8})$$

$$\tilde{c} = \underbrace{\left( 1 + \frac{\zeta B}{1-\zeta B} \varepsilon_{Bz} \varepsilon_{Zv+} [\varepsilon_{Sf} \sigma_{vf} + (1-\varepsilon_{Sf})\sigma_{cs}] \right)}_{\equiv \varepsilon_{Cv}} \tilde{v} + \left( \frac{\sigma_{vf} - \sigma_{cs}}{\sigma_{vf} - 1} \varepsilon_{Sf} \right) \tilde{\phi} + \tilde{\mu} + \sigma_{cs} \tilde{w}. \quad (\text{A.9})$$

$$\tilde{l} = \underbrace{\frac{1}{l} [-v - f\varepsilon_{Fv} + z\varepsilon_{Zv+} + (v + (1-v)\varepsilon_{Bz}\varepsilon_{Zv+})(1+\zeta)B]}_{\equiv \varepsilon_{Lv}} \tilde{v} - \left( \frac{f}{l} \right) \tilde{\phi} + \frac{1}{\psi l} \tilde{\psi}, \quad (\text{A.10})$$

Equation (A.10) is the log-linear equivalent of (14) in the main text; it is used to determine the partial derivatives of the function  $L$ . To simplify, and consistent with (1), from now on we restrict the analysis to  $\sigma_{cs} = 1$ . Solving (A.8), (A.9) and (A.10) for  $v$  and  $l$ , we find:

$$\tilde{v} = \frac{-1}{\varepsilon_v} \left[ \varepsilon_{Sf} \tilde{\phi} + \tilde{\mu} + \left( \frac{w}{(1+\delta)c} \right) \frac{1}{\psi} \tilde{\psi} \right], \quad (\text{A.11})$$

$$\tilde{l} = - \left( \frac{\varepsilon_{Lv}}{\varepsilon_v} \varepsilon_{Sf} + \frac{f}{l} \right) \tilde{\phi} - \left( \frac{\varepsilon_{Lv}}{\varepsilon_v} \right) \tilde{\mu} + \left( \frac{\varepsilon_{Cv} - \varepsilon_{Tv}}{\varepsilon_v} \right) \frac{1}{l\psi} \tilde{\psi}. \quad (\text{A.12})$$

where

$$\varepsilon_v = 1 + \frac{\zeta B}{1-\zeta B} \varepsilon_{Bz} \varepsilon_{Zv+} [\varepsilon_{Sf} \sigma_{vf} + (1-\varepsilon_{Sf})] + \frac{wB}{(1+\delta)c} [v + (1-v)\varepsilon_{Bz} \varepsilon_{Zv+}] > 0.$$

Note that (A.11) is the linearized version of (16) in the main text. Increases in  $\psi$ ,  $\mu$  and  $\phi$  raise equilibrium bridging capital  $v$ , see (A.11). Since the sign of  $\varepsilon_{Lv}$  is ambiguous, the effect of changes in  $\mu$  and  $\phi$  on equilibrium learning time  $l$  is ambiguous, see (A.12). Since it can be proved that  $\varepsilon_{Cv} > \varepsilon_{Tv}$  (see below), an increase in  $\psi$  increases  $l$ .

Proof  $\varepsilon_{Cv} > \varepsilon_{Tv}$ .

Now consider possible corner solutions. The CES formulations of the (sub)utility function implies that  $c, c_o, v, f$  are all strictly positive, and the first-order conditions hold with equality. We combine the associated first-order conditions and budget constraint, (A.1), (A.2), and (A.3), to derive the following expression (for  $\sigma_{cs} = 1$ ):

$$\begin{aligned} \tilde{v} \left\{ 1 + \frac{w}{(1+\delta)c} [v + f - v\zeta B] \right\} = \tilde{z} \left\{ \left( \frac{\varepsilon_{sf} \sigma_{vf} + 1 - \varepsilon_{sf}}{\sigma_{vf}} \right) \varepsilon_{Fz+} + \frac{w}{(1+\delta)c} [f \varepsilon_{Fz+} - z - (1-v)\zeta B \varepsilon_{Bz}] \right\} \\ - \left( \frac{wl}{(1+\delta)c} \right) \tilde{l} - \tilde{\mu} - \left[ \varepsilon_{sf} + \frac{wf}{(1+\delta)c} \right] \tilde{\phi} \end{aligned} \quad (\text{A.13})$$

The marginal benefits of an increase in  $z$  are  $(1-v)B_z w$  (LHS of (5)), while the marginal costs are  $w$  (RHS of (5)). Hence, marginal benefits are larger (smaller) than marginal costs if:

$$\tilde{v} < - \left( \frac{1-v}{v} \right) \left( \frac{-B_{zz}(z)z}{B_z(z)} \right) \tilde{z} \quad (\text{A.14})$$

An interior solution requires that (A.13) and (A.14) hold with equality. The second order condition for this equilibrium requires that when  $z$  is slightly lower than in the equilibrium, and when all other variables are adjusted such that the FOCs for  $c, c_o, v, f$  still hold, the marginal benefits of  $z$  should exceed the marginal costs. In other words, if we draw (A.13) and (A.14) in a  $z, v$  plane, the locus corresponding to (A.13) should cut the locus corresponding to (A.14) from below for the equilibrium to be “stable” (second order condition fulfilled). From (A.13) and (A.14), this requires  $\varepsilon_{Cv} > \varepsilon_{Tv}$ , where  $\varepsilon_{Cv}$  and  $\varepsilon_{Tv}$  are defined in (A.8) and (A.9).

If  $z = 0$ , we have, from the definitions,  $\varepsilon_{Cv} - \varepsilon_{Tv} = (1-l)w/(1+\delta)c > 0$ ,  $\varepsilon_{Lv} = -(v+f)/l < 0$ .